

or pseudoposematic; certain stages in the life of an individual may be cryptic, others aposematic or pseudoposematic. There is nothing subversive in the thought that certain species exposed to different organic environments in two seasons of the year may appear as cryptic generations at one of these, aposematic or pseudoposematic at the other. The explanation is at any rate sufficiently probable to enable us to contemplate Mr. Marshall's wonderful discovery with equanimity and with an interest undisturbed by the thought that he has laid in ruins the whole edifice of insect systematics.

29. THE GREGARIOUS INSTINCT IN HYBERNATION AND EMIGRATION OF INSECTS. (E. B. P.)

The interesting observation that individuals of *Precis sesamius* are apt occasionally to congregate in large numbers as they go to roost, led me to reflect on the possible meaning of such an instinct. Mr. Marshall records other examples of the same kind "in species of *Euralia*, also in *Belenois*, *Herpania eriphia*, and *Teracolus eris*" (Ann. and Mag. Nat. Hist., *loc. cit.*, 1898, p. 34). It is possible that one interpretation does not explain all these cases, but I think it is probable that the observed instances of the congregating of *Precis* and *Euralia* are sporadic examples of an instinct which is associated with hibernation or, at any rate, a prolonged period of rest during a time of relatively excessive cold, heat, or dryness. Objection may be taken to this interpretation on the ground that large companies undergoing a prolonged rest ought to be well known in these species. It is possible however that the extreme conditions which render such a state desirable or even necessary for the species are not common, and, when they occur, do not conduce towards the active pursuit of natural history; furthermore, such prolonged rest would probably be passed through in some hidden recess which could only be found by accident.

Large numbers of naturalists for hundreds of years have been interested in the doings of *Vanessa io*, but, so far as I am aware, it is not generally known that this species may display a gregarious habit in hibernation.* My friend,

* Edward Newman recorded the occurrence of a company of more than forty *V. io* in a hollow oak (British Butterflies and Moths, London, N.D., p. 16), and the Rev. Joseph Greene disturbed three

Dr. W. Hatchett Jackson, the Radcliffe Librarian at Oxford, permits me to publish the following observation made by him at Weston-super-Mare in the second week of January 1895. Dr. Jackson found, in the garden of his house, on the side of a hill sloping south, about twenty peacock butterflies hybernating in the heart of a bramble-bush. The butterflies were arranged in rows on two or three approximately horizontal runners about a foot from the ground. All rested with their wings hanging downwards. When the butterflies were first disturbed they made no movement, but on repeated disturbance they

specimens in the hollow formed by the arching roots of a large beech-tree, in Dec. 1852 (G. C. Barrett, British Lepidoptera, London, 1893, vol. i, p. 139). W. S. Coleman (British Butterflies, London, 1862, p. 88) quotes Doubleday in the *Zoologist*:—"Last winter some large stacks of beech faggots, which had been loosely stacked up in our forest (*Epping*) the preceding spring, with the dead leaves adhering to them, were taken down and carted away, and among these were many scores of *io*, *urticeæ*, and *polychloros*." No reference is given, and I have failed to find the original statement. An observation of Mr. Banning of Monte Video, Ballacrairie, Isle of Man (also quoted by Coleman, l. c. p. 91), is recorded in the *Zoologist* (1856, p. 5000):—"Whilst standing in my farmyard on the day following Christmas Day [1855], it being unusually fine and warm, I was suddenly astonished by the fall of more than a hundred of the accompanying butterflies [*Vanessa urticæ*]. I commenced at once collecting them, and succeeded in securing more than sixty. . . ." This observation apparently points to the emergence of a hybernating assemblage in consequence of exceptionally warm weather. It also indicates conditions which at a normal time of the year would be favourable to pairing.

Mr. J. W. Tutt states that the imagines of *V. io* feed largely during August, disappearing at the end of the month or in September (*Entomologist's Record*, 1895-6, vol. vii, p. 3). It is therefore probable that the butterflies produced by one company of larvæ do not keep together, or the fact would certainly have been noticed when they are in search of food. It is probable that the products of all companies scatter and become thoroughly intermingled before again assembling into groups for hybernation. Another line of evidence may perhaps yield incontrovertible proof of the existence of this intermixture before reassembling—a probable adaptation to prevent in-and-in breeding. Dr. W. H. Jackson and Mr. O. H. Latter, F.E.S., have found that the pupæ obtained from different batches of larvæ of *V. io* "were principally, but not entirely, of one or of the other sex" (*Trans. Linn. Soc., London*, vol. v, 1890, p. 156). It would not be difficult to obtain a numerical statement of the average constitution of a company in this respect, so that it would be available for comparison with that of a hybernating group. A marked difference would prove intermixture before hybernation, while a similar constitution would yield negative evidence.

flicked their wings and the movement passed along the row. It must be remembered that the climate of Weston is extremely mild, and the great frost of 1895 had not then begun.

The advantages of a period of rest during excessive heat and dryness may be as great as those which follow from excessive cold. In the former the food-plant may be parched and dry or confined to very few and widely-scattered damp spots, and the perfect insect may pass through its life without the chance of laying eggs in places where the larvæ would be able to survive. But quite apart from this, the continuous excessive drought may be injurious to the perfect insect itself. At the driest and hottest part of the African dry season a great scarcity even of common butterflies has been noticed, and it is not unlikely that many individuals of some species pass through the most critical period of very dry and hot years concealed in a state of rest. It is significant that the congregating instinct has only been observed in the dry phase of *Precis sesamus*.

This does not solve the problem of the gregarious instinct itself. It is clear that Dr. Jackson's observation on *V. io* and Mr. Marshall's on *Precis*, etc., indicate the existence of an instinct which must be a real and great danger to the species. The less the individuals congregated and the more widely they scattered, the greater would be their chance of safety. A fortunate enemy finding one of the peacocks in the bramble-bush at Weston would have secured the whole. It is therefore certain on the principles of natural selection that some great advantage is gained by the instinct, an advantage which more than compensates for the increased danger. I would suggest that this advantage is the facility given for pairing and the laying of eggs without any loss of time, as soon as the period of rest comes to an end. The advantage would be quite as great or even greater after the rest during drought than after ordinary hibernation, because of the rapidity with which the food-plant recovers with the first moisture. It would be interesting to consider from this point of view the food-plants of the African species in which the instinct has been observed.

This suggestion naturally leads to a consideration of the gregarious instinct in the peculiar form of emigration which has been observed in insects. The same increased

dangers attend the phenomenon, and I think it is very probable that they are more than compensated by the analogous benefits. The instinct to emigrate probably exists in a dormant state in all species liable from their powers of rapid multiplication suddenly to outrun the food-supply in any part of their range. The stimulus which evokes the instinct is, in such insects as the locust, or such mammals as the lemming, probably merely the direct and obvious incentive of hunger (A. R. Wallace, "Geographical Distribution," London, 1876, vol. i, p. 18). In the majority of perfect insects, however, we cannot accept this interpretation, and we are compelled to look for a stimulus in some other result of undue increase—the crowds of individuals everywhere, the food-plant covered with eggs and young larvæ, and females laying still more eggs. Then probably arises the imperative instinct to move, perhaps in both sexes, perhaps only in the female, the males accompanying them (in many species in far larger numbers). And the instinct further compels the individuals to move together in vast masses in the same direction, rather than to scatter and fly in all directions. The increased danger from enemies is of course lessened, as compared with the hibernating companies, by the enormous number of emigrating individuals; but there is, I believe, the solid advantage that fresh food-plant may be found in another uncrowded area; that the limits of the normal range of the species may be overpassed; that areas from which the species has been driven may be regained:—not by single individuals or by a very few pairs, but by immense numbers of both sexes without any of the dangers of in-and-in breeding when once they have established themselves as a fresh colony. In this way the range of many species has probably been extended in the past, and, although the emigrating crowds so often described may again and again be landed in a foodless desert or the sea, the instinct is advantageous in that it utilizes individuals which are at the moment useless and even injurious to their kind, in a manner which may be in a high degree beneficial (see also Trimen, "South African Butterflies," vol i, 1887, p. 31). The suggestion is made that the crowded masses, resulting from overproduction and inability of enemies to cope with the increase, are injurious to the species, because it is likely that food-plants would be checked for years or even killed

out altogether in certain localities, while the heaps of dead individuals would encourage the attack and rapid spread of bacterial foes. Indeed, the advantages to be derived from the removal of the surplus from an overcrowded area may probably outweigh those which accrue from the occasional successes in colonization, and may more than the latter account for the development by natural selection of the instinct to move. The massing of the moving individuals and their flight in the same direction seem, on the other hand, to have arisen by selection from the beneficial results conferred by spreading into less crowded areas. It is difficult to imagine any other possible means by which such animals as insects could overcome the effects of a sudden increase too great for the restraining influences of their natural enemies—effects which insufficiently checked for a few generations would inevitably lead to the destruction of the species in the area of over-production.

We may well inquire why it should be necessary for such emigration, with a possible successful issue in colonization, to require the services of countless individuals when the importation of half-a-dozen rabbits or a few specimens of *Pieris rapæ* will, for the naturalist, change the face of a continent. The results of these unintentional, or intentional but ill-considered, experiments do indeed shake the belief in the paramount necessity for crosses and the dangers of in-and-in breeding; but the end is not yet, and the teeming colonies which have arisen from such small beginnings may in time vanish from the operation of deep-seated causes. The varied adaptations for cross-fertilization and the prevention of in-and-in breeding are so evident in nature, that we are compelled to believe that they meet and counteract serious dangers which sooner or later would menace the very existence of the species. And among other adaptations it is significant that the instinct under discussion should lead to the streaming of large populations, and not of small batches of individuals from an area of high pressure.

The gregarious instinct in emigration has been observed in many groups of insects beside the Lepidoptera. I need only mention here the hundreds of *Ammophila hirsuta*, ordinarily a solitary species, found by Fabre under a large flat stone on the summit of Mont Ventoux at a height of 6000 ft., and the crowds of ladybirds witnessed by him

on the same mountain and on the tableland of St. Armand ("Insect Life," English translation, London, 1901, p. 193). A valuable account of a large number of observations will be found in Mr. J. W. Tutt's numerous papers on "The Migration and Dispersal of Insects" (Ent. Record, 1898-1902). The author recognizes the dangers of over-multiplication as a cause of migration (l. c. vol. xii, 1900, p. 238: see also vol. xiii, 1901, p. 200). Numerous examples quoted by him prove that movement in vast bands, often at great distances from land, has been observed again and again in those very species which are remarkable for their wide geographical distribution and occurrence upon oceanic islands. The appearance of two species of *Hybernia*, *H. defoliaria* and *H. aurantiaria*, observed in large numbers in Heligoland by Gätke, cannot be explained on the hypothesis here suggested because, the females being flightless, males only appeared. In several other instances recorded by Mr. Tutt the presence of both sexes is either specially affirmed or implied. In the great majority of cases, however, no observations of sex were made, and it is to be hoped that careful attention may be paid to this point in the future. The proportion of females to males would also be deserving of careful investigation.

The limits of this memoir are perhaps too wide already, and it is impossible to attempt any discussion of these observations in detail, but I have taken the opportunity of making a suggestion as to the possible essential meaning of the instinct.

I have deliberately used the word "*emigration*" of insects, because this term probably expresses the exact state of the case. In response to some stimulus connected with undue increase, immense masses of individuals *move out of* an overcrowded area. The line of movement may carry them to destruction or to plenty, in both cases benefits are probably gained, although they are of course much greater in the latter. True "*migration*" as of birds and perhaps of fishes implies different and far higher faculties—the memory of the individual summed up by tradition into what may be called the collective memory of the species.